Indian J. Phys. **49**, 877–888 (1975)

Diurnal variation of 5577 Å line intensity of night airglow at Allahabad

NAMITA KUNDU AND S N GHOSH*

J K. Institute of Applied Physics and Technology, University of Allahabad, Allahabad

(*Received* 23 *July* 1975)

The characteristics of the diurnal variation of 5577 Å line intensity of night airglow at Allahabad are observed A number of IGY observation stations are chosen around the same latitude range as that of Allahabad The normalised data for all these stations and those obtained at Allahabad are plotted seasonwise and are compared In general two maxima are observed during a night The early morning maximum is less pronounced than the first maximum around the local midnight. Again, the monthly mean diurnal variation curves show a maximum around midnight and an early morning maximum around 03 hr The time of occurrence of midnight maximum changes with the time of the year. It is further observed that although the diurnal variation of 5577 Å line intensity depends on the latitude of the station there is also a longitudinal effect

1. INTRODUCTION

Ever since the identification of 5577 Å line in 1927 by MacLennel and his associates, observations of the nightly intensity variations of this line have been recorded. Photoelectric recordings were made by Barbier *et al* (1951, 1953), Roach *et al* (1953, 1954), Barbier (1956), Manring & Pettit (1956) Recent observations with rocket-borne or ground-based instruments are recorded by Johnatsu & Nagata (1963), Kulkarni (1965), Greer & Best (1967), Gordon (1968), and Schaeffer *et al* (1971)

It is seen that the diurnal variation of 5577 Å line intensity is irregular and complex in nature. In the northern latitudes in the course of a night generally one or more maxima are observed A maximum is usually observed around local midnight. The time of occurrence of the maximum at any station changes with the season At lower latitudes such as Mount Abu (latitude 24°36′ North). Poona (latitude 18°31′ North) and Allahabad (latitude 25°32′ N) a second early morning maximum is also observed

*Present address : Department of Applied Physics, University College of Science, Calcutta-700009.

It is further observed that the diurnal variations of 5577 Å line intensity at stations situated in the equatorial region and in the southern hemisphere are quite different from the variations of intensity observed at stations situated in the northern temperature latitudes. Silverman's (1964) analyses of 5577 Å airglow emission data from Tonantzintla (Mexico), Huancayo (Peru), San Juan (Argentina) and Lwiro (Congo) show that the midnight maximum does not occur in the southern latitude stations. The intensity decreases during the early part of the night and then increases in the later part after passing through a minimum

Brenton & Silverman (1970) made a statistical study of the diurnal variation of zenith intensity of 5577 Å line obtained from 22 stations distributed throughout the world. The data from 19 stations were obtained from the Annals of the International Geophysical Year (Yao 1962) from participating stations in the IGY-IGC (July 1957 to December 1959) programme. To establish correlation of the pattern of diurnal variation of 5577 Å line with the geographic or geomagnetic co-ordinates, the curves of the diurnal variation of the line were arranged by geographic latitude and longitudide, by geomagnetic latitude and by dip latitude. But none of these arrangements showed the diurnal variation of 5577 Å line intensity as a simple function of the geographic or geomagnetic co-ordinates. Only the overall diurnal variations show some general characteristics at different latitudinal regions. The data from different stations are arranged in 10° latitudinal belts. At stations north of 40°N latitude but not in the auroral zone, the intensity does not show significant diurnal variation. In the latitudinal interval from 40°N to 20°N, the intensity shows a pronounced maximum during a night In the region south of 20°N latitude the intensity of 5577 Å line attains a minimum during the night and furthermore the diurnal variation is significant To bring out clearly the variations of 5577 Å line intensity with geographic latitude, Brenten & Silverman (1970) averaged the diurnal variations at stations located in belts of 10° latitude, The average diurnal variations in the belts of 60–50°N, 50–40°N, 40-30°N, etc. are shown in figure 1 The variability of the data from different stations is smoothened by averaging and shows clearly the three classifications of diurnal variations and the reversal from midnightly maximum to minimum at about 20°N latitude. To show the seasonal effect the data was divided into four seasonal groups-winter, spring, summer and autumn. For stations like Mt Abu, Poona and Allahabad only winter and spring data are available.

It is however to be noted that, if the monthly mean diurnal variation is studied for a station, it is seen that averaging over a season or over an year may be misleading The variations at Sacramento Peak show a marked change from month to month But by averaging of data the curve smoothens out

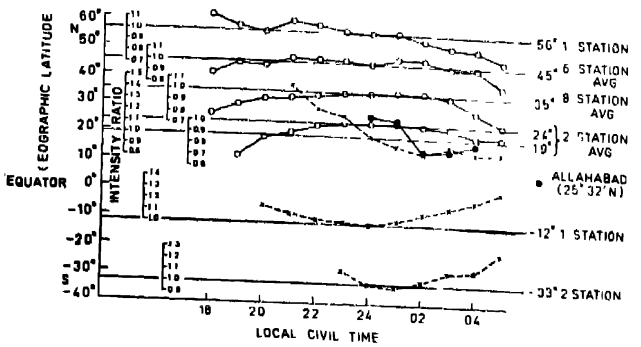

Fig. 1. Average diurnal variations of 5577 Å line intensity in the night airglow for IGY stations in 10° latitude belts and that for Allahabad (25°32'N, 81°53'E). It is to be noted that the intensities for IGY airglow stations were normalised at midnight whereas that for Allahabad at 01 hr

3 Observations at Allahabad

Observations at Allahabad are made on dark nights with clear sky conditions from September 1970 to March 1971 Variations of zenith intensity for 9 nights are discussed

Observations made at Allahabad (India) is compared with those of other stations viz , Sacramento Peak (U.S.A.), Mount Abu (India), Tamanrasset (Sahara), Tonantzintla (Maxico) and Poona (India). All the stations lie within the latitudinal interval from 32°N to 18°N. They are however situated at widely different longitudes.

3.1 *Analysis of Data*

The variation of 5577 Å line intensity is moderate during normal nights . The nights during which large intensity variation occurred are classified as abnormal. The nights 1/2 Oct 1970 (figure 3), 1/2 Nov 1970 (figure 4) and 2/3 March 1971 (figure 2) are observed to be abnormal In general, two maxima are observed during a night In most cases the first, maximum is more pronounced than the late or early morning maximum The nights of 1/2 Oct. 1970 (figure 3), 2/3 Nov. 1970 (figure 4), 23 Feb/1 March 1971 (figure 2) exhibit such behaviour

Only in two nights viz., 31 Oct /1 Nov. 1970 (figure 4) and 1/2 Nov 1970 (figure 4) the early morning maximum is pronounced. The late maximum of 1/2 Nov 1970 (figure 4) night appears to be more pronounced than the midnight maximum. The relative amplitude of the early morning maximum changes with time. During Sept.-Oct. 1970 the late maximum was very small During Nov. 1970 in general it is pronounced as exhibited on 31 Oct./1 Nov. 1970 (figure 4),

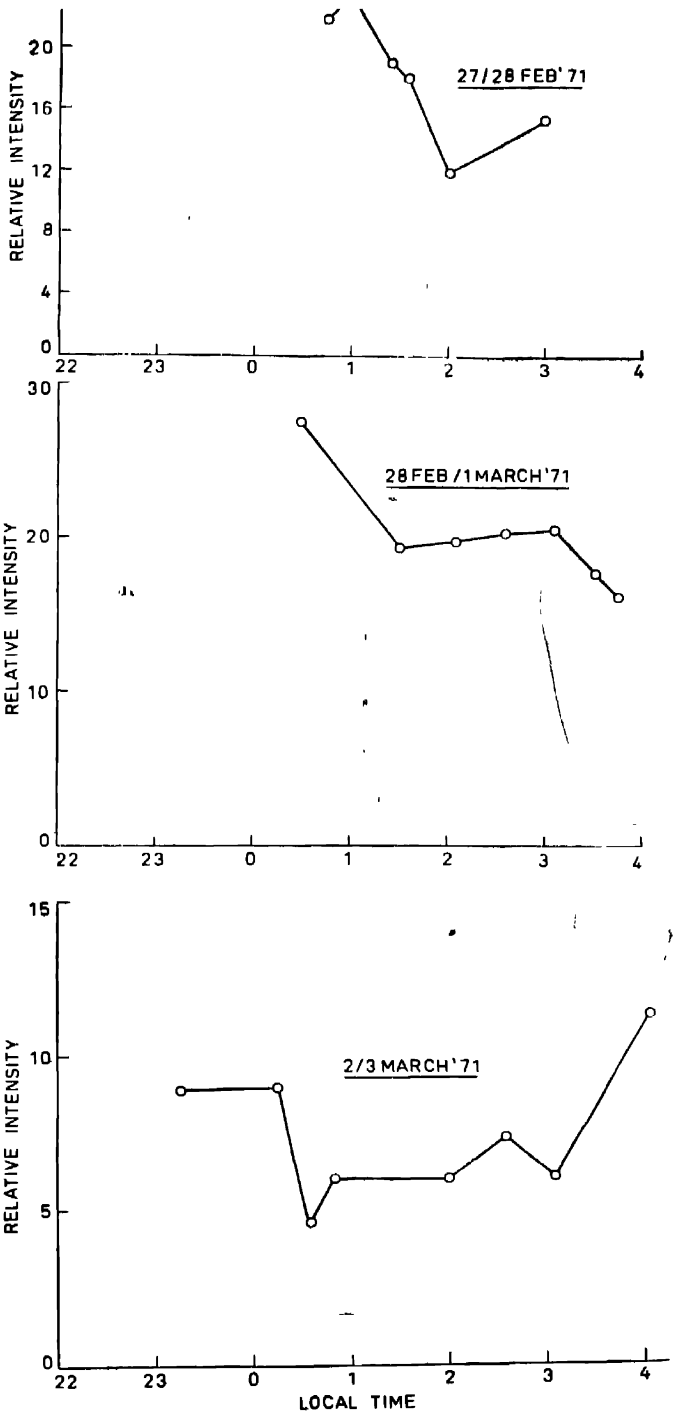

Fig 2. Diurnal variations of 5577 Å line intensity in the night airglow at Allahabad with respect to local time for the nights of 27/28 Feb, 28 Feb/1 Mar, and 2/3 Mar 1971

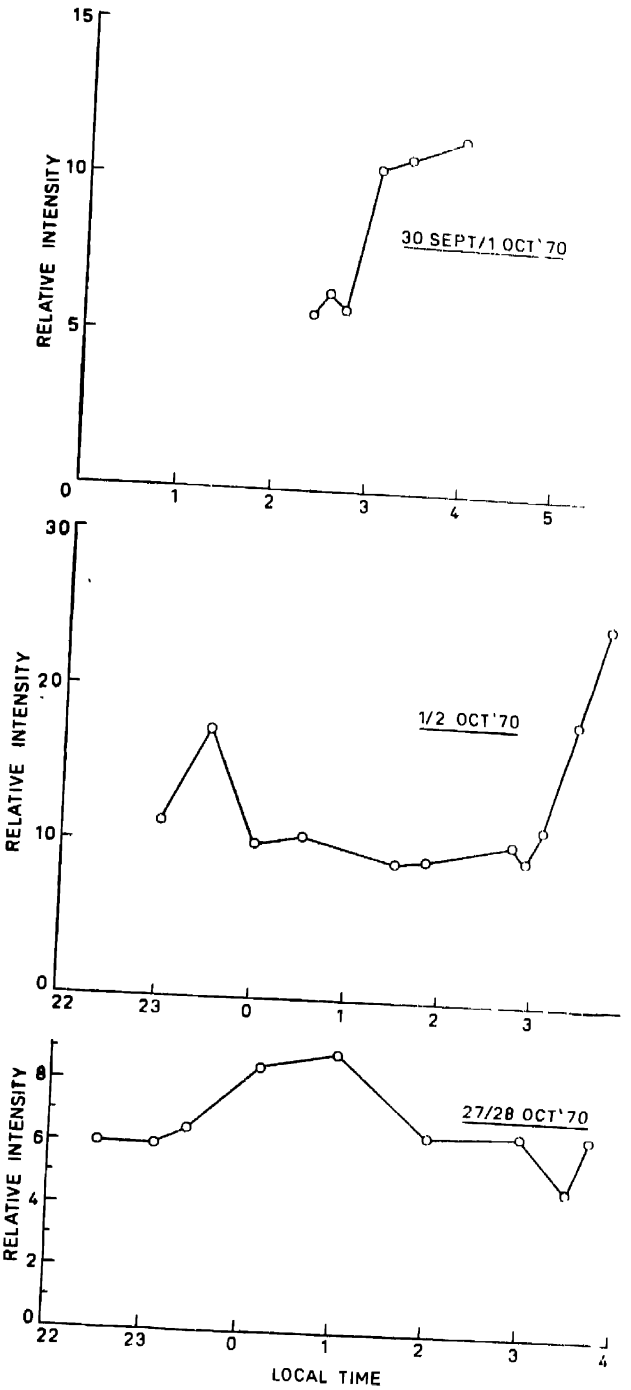

Fig. 3 Diurnal variations of 5577 Å line intensity in the night airglow at Allahabad with respect to local time for the nights of 30 Sept./1 Oct., 1/2 Oct. and 27/28 Oct. 1970.

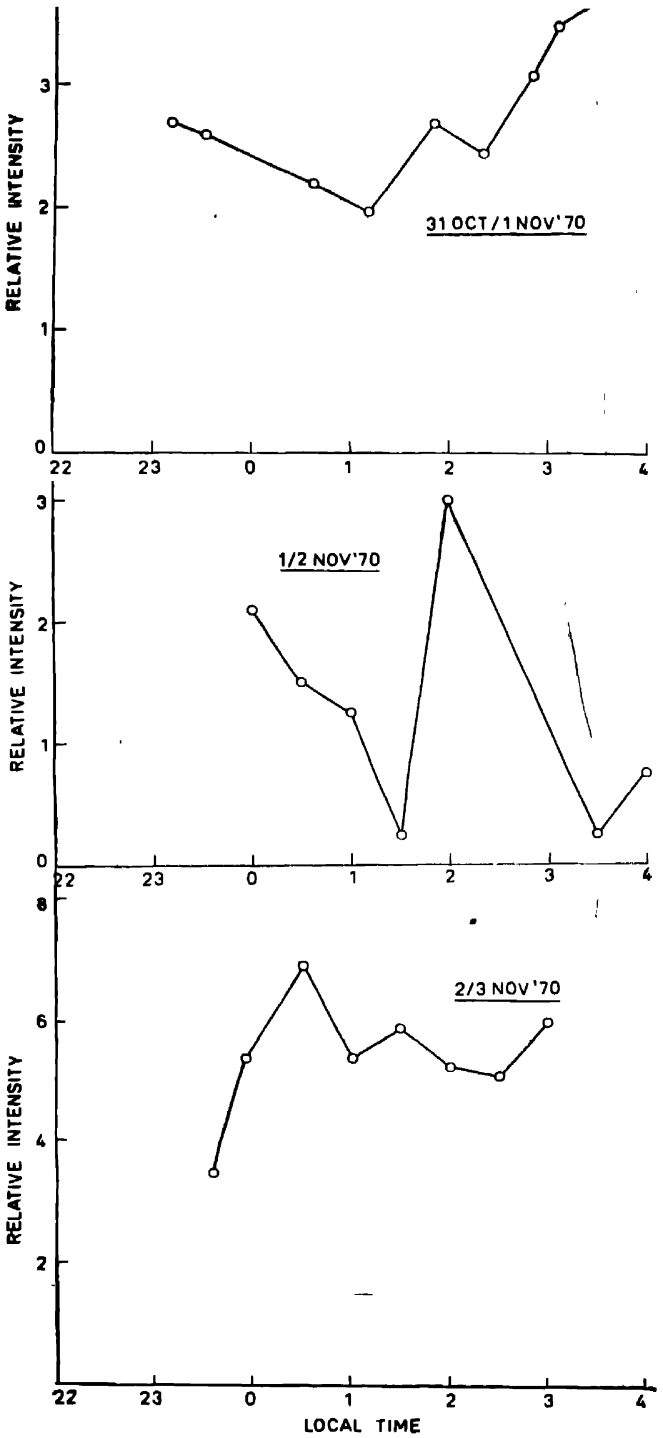

Fig. 4. Diurnal variations of 5577 Å line intensity in the night airglow at Allahabad with respect to local time for the nights of 31 Oct./1 Nov., 1/2 Novi., 2/3 Nov. 1970.

1/2 Nov. 1970 (figure 4) and 2/3 Nov 1970 (figure 4) nights. The intensity level of 5577 Å emission was low during this period As spring approached the intensity level of emission increased but the relative intensity of the second maximum decreased as shown on the nights of 28 Feb /1 March 1971 (figure 2), 2/3 March 1971 (figure 2). The variation of relative intensity of the late maximum is shown clearly in figure 5 (graph for monthly mean diurnal variation) The characteristics of nightly variation of the intensity of 5577 Å line in night airglow as observed at Allahabad and the corresponding solar and geophysical data are compared

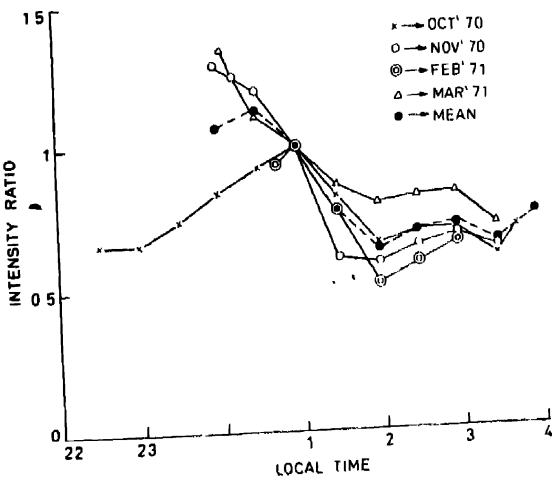

Fig. 5 Monthly average and the mean diurnal variation of 5577 Å line intensity normalised at 01 hr with respect to local time at Allahabad.

4. Discussion

Monthly mean diurnal variation of 5577 Å *line intensity*

Data for 5577 Å line intensity for each month is normalized by Silverman's (1964) ratio method. The zenith intensity of this line measured at 01.00 hr. every night is taken to be unity Each half-hourly observations are reduced with respect to it. To obtain the monthly mean diurnal variation curves, the ratio for each half hourly data is averaged for all available days of the month. Figure 5 shows the curves for the mean diurnal variations for four months, Oct. 1970, Nov. 1970, Feb. 1971, March 1971 and the mean curve. It is seen that during the month of October 1970 the intensity had a peak at 01.00 hr., whereas during the months of Nov. 1970 and March 1971, the peak had occurred before midnight. During the month of Feb. 1971, there was a tendency to have a maximum at 01.00 hr. After 01.00 hr. all curves for mean diurnal variation

are strikingly similar in nature Each curve exhibited the lowest value at 02 00 hr and the early morning maximum at 03.00 hr. After 03.00 hr. the intensity fell to a lower value at 03.30 hr. and then increased slowly. Similarly early morning minimum was also observed at Dumka (24°16′ N, 87°15′ E), India as reported by Singh (1970). The mean diurnal variation curve observed at Mt Abu and Poona, specially for the winter season as quoted by Brenten & Silverman (1970) also showed early morning maxima at about 04.00 hr

The mean curve for the monthly diurnal variation of 5577 Å line intensity shown in figure 5 appears to be of sinusoidal form with two peaks of unequal amplitude

Seasonal Effect on Diurnal Variation of 5577 Å *Line Intensity*

To eliminate the effects of seasonal changes on the diurnal variation of 5577 Å line intensity the mean diurnal variations at different seasons were plotted. The daily intensity is normalized by considering the zenith intensity at 01 00 hr to be unity For each point the average of relative intensity ratios of all available days in each season was considered. It is to be noted that the observations were taken during the winter and spring seasons During summer, reliable data could not be obtained due to too much dust particles in the atmosphere Again during rainy season no observation could be made due to cloud coverage of the sky

Winter

The intensity of 5577 Å line at Allahabad during winter is plotted in figure 6 The principle maximum appeared to occur before midnight. The intensity fell gradually uptil 1.00 and then sharply till 02 00 the lowest value during a night was attained at 02 00. The intensity increased slightly till 03 00 which is the early morning maximum and then decreased till 03 30. The range of variation of intensity ratio was small, about 0.5 from 1 1 to 0 6.

Similar analysis of the 5577 Å line intensity curve for Sacramento Peak, New Mexico (32°45′ N, 105°45′ W) in winter shows a different type of variation The intensity variation is sinusoidal in shape with the peak at 00 hr. There is no secondary maximum and the range of variation is very small, about 0.2

Three stations have nearly the same latitude viz , Allahabad, India (25°32′N) 81°53′E), Mt. Abu, India (24°36′N, 72°43′E) and Tamanrasset, Africa (22°48′N, 5°31′E). Just like Allahabad, Mt Abu shows an early maximum in winter The IGY data show the maximum at 21 hr. But at Tamanrasset a broad maximum was observed in winter from 01 to 03 hr. The intensity variations at both places were small, about 0.15. The early morning maximum at Mt Abu in winter occurred at 01–04 hr. Tamanrasset showed no such second maximum

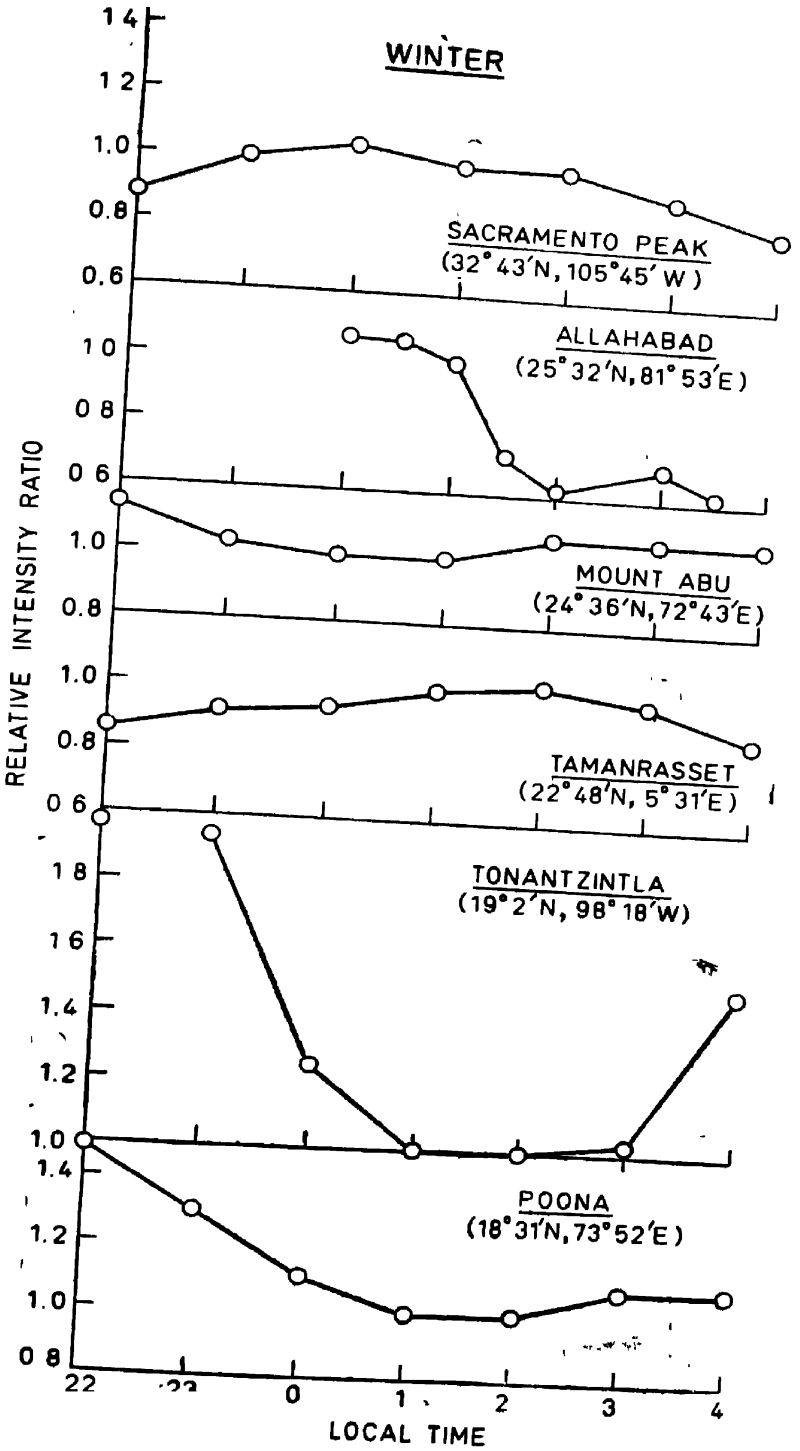

Fig. 6. Diurnal variation of 5577 Å line intensity during winter season for Sacramento Peak, Allahabad, Mt. Abu, Tamanrasset, Tonantzintla and Poona.

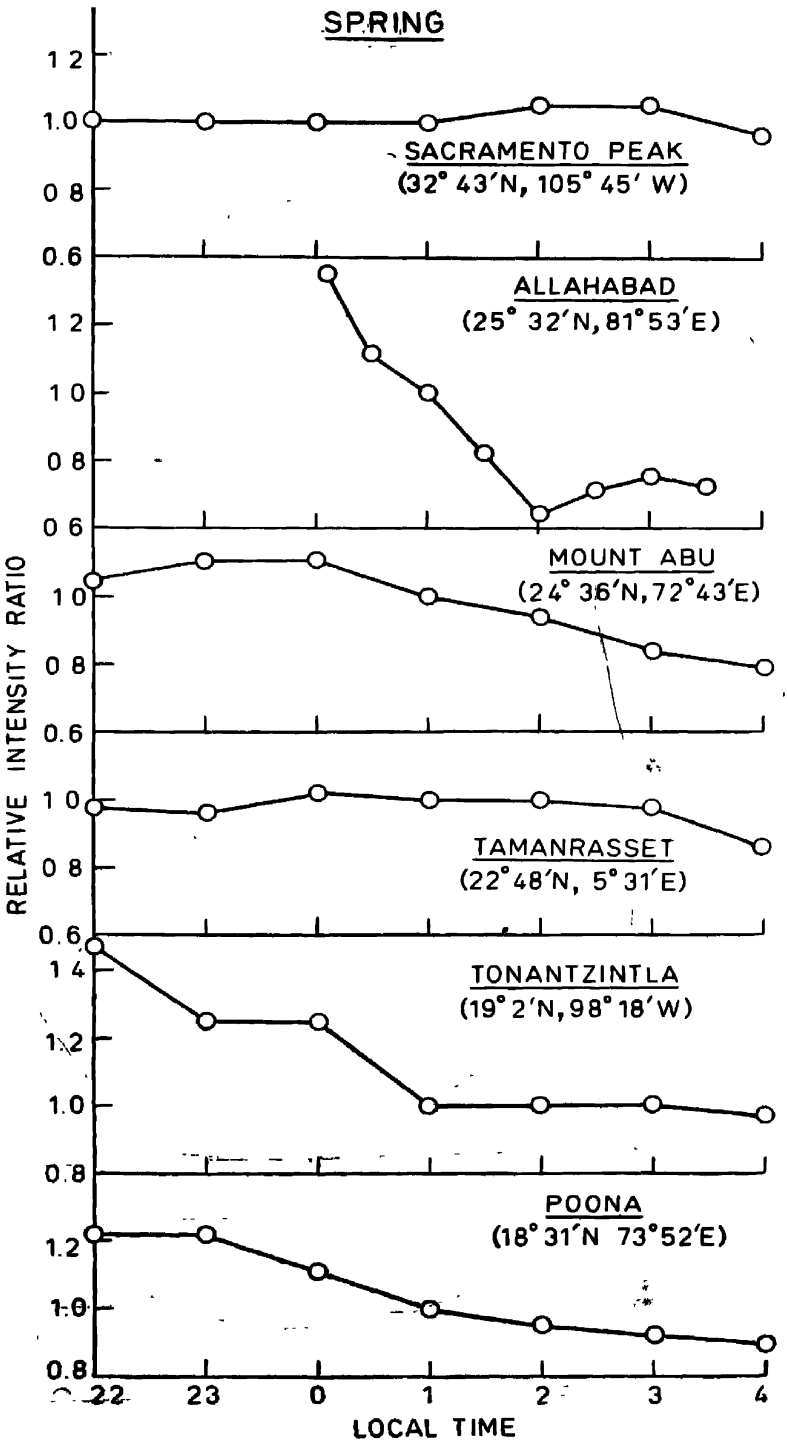

Fig. 7. Diurnal Variation of 5577 Å line intensity during spring season for Sacramento Peak, Allahabad, Mt Abu, Tamanrasset, Tonantzintla and Poona.

during the night Hence, the observations recorded at Mt Abu are in agreement with those at Allahabad. The data at Allahabad and those of Tamanrasset do not agree fairly well

Both Tonantzintla, Mexico (19°02′N, 98°18′W) and Poona, India (18°31′N, 73°52′E) are at lowest latitudes But the trend of variation at the two places are very different The variation at Poona is more or less same as those of Mt Abu and Allahabad It shows an early maximum followed by a minimum at 01–02 hr The early morning maximum occurs at 03-04 hr The range of variation is 0 5 between 22 hr to 04 hr At Tonantzintla the intensity ratio did not show any maximum, rather it passed through a minimum Also the total variation is larger of the order of unity

Spring

The intensity curve for spring at Allahabad shows larger variation (about 8) and the principle maximum is more pronounced (figure 7) The intensity decreases to the all-night minimum at 02 hr. An early morning maximum is seen at 02 30 hr, but it is less pronounced than that in the winter

The intensity variation at Sacramento Peak is very small having a broad maximum at 02–03 hr The trend of variation does not agree with that at Allahabad

At Tamanrasset the intensity variation is very small with a broad flat maximum from 00–03 hr On the other and, at Mt Abu the range of variation (0 3) is more than that during winter. The principle maximum is observed at 23 hr No second maximum is observed At Poona the principle maximum is observed at 22–23 hr No early morning maximum is exhibited The intensity variation is about 0 3 On the other hand at Tonantzintla there is a gradual fall of intensity with the progress of night No principle maximum is seen

5 Concluding Remark

From the above discussion, it is seen that the diurnal variation of 5577 Å line intensity depends on the latitude of the station However, the variation does not depend wholly on latitude There is also a longitudinal effect

References

Barbier D. 1956 *The Airglow and the Aurora*, edited by Armstrong and Dalgarno, Pergamon Press, Oxford, p. 38

Barbier D., Dufay J & Williams D 1951 *Ann. Astrophys* **14**, 399

Barbier D., Dufay J. & Williams D 1954 *Proceeding of the Conference of Auroral Physics*. Edited by Gersen, Keneshea, Donald Sen p. 137.

Brenten J. C. & Silverman S. M 1970 *Planet Space Sci.* **18**, 641

Gordon M. A 1968 *Planet Space Sci.* **16**, 297.

Greer R. G. H. & Best G. T. 1967 *Planet Space Sci* **15**, 1857.

Kulkarni P. V. 1965 *Ann. Geophys.* **21**, 58

Manring E. R. & Petit H. B. 1956 *The Airglow and Aurora*, Edited by Armstrong & Dolgarno, Pergamon Press, Oxford, p. 29

Roach F. E., Petit H. B., Williams D. R., St. Amand P. & Davis D. N. 1953 *Ann. Astrophys* **16**, 185

Roach F. E., Williams D. R., St. Amand P., Pettit H. B. & Welden R. G. 1954 *Ann. Astrophys* **17**, 172

Schaeffer R. C. & Jacka F. 1971 *Jour. Atmos. Terr. Phys* **33**, 229.

Singh J. 1970 Thesis, Jadavpur University, Calcutta, India.

Silverman S. M. 1964 *Planet Space Sci.* **12**, 247.

Tohmatsu T. & Nagata T. 1963 *Planet Space Sci.* **10** 103

Yao I. G. 1962 (Editor). *Ann. Int. Geophys. Year*, Pergamon Press, Oxford, 24, Observation of Night Airglow, 1 July 1957–31st Dec. 1959.